PCT/AU98/01077

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I, KIM MARSHALL, MANAGER EXAMINATION SUPPORT AND SALES, hereby certify that the annexed is a true copy of the Provisional specification in connection with Application No. PP 1112 for a patent by PARAKAN PTY LTD and ILAMON PTY LTD filed on 24 December 1997.

I further certify that the above application is now proceeding in the name of MAGELLAN TECHNOLOGY PTY LIMITED, PARAKAN PTY LTD and ILAMON PTY LTD pursuant to the provisions of Section 113 of the Patents Act 1990.

WITNESS my hand this Twenty-first day of January 1999

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MANAGER EXAMINATION SUPPORT AND SALES

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AUSTRALIA

PATENTS ACT 1990

PROVISIONAL SPECIFICATION

FOR THE INVENTION ENTITLED:-

"A TRANSMITTER AND A METHOD FOR TRANSMITTING DATA"

The invention is described in the following statement:-

Field of Invention

The invention relates to a transmitter and a method for transmitting data.

The invention has been developed primarily for the field of radio frequency identification (RFID), and more particularly to a method for transmitting data to a transponder with a single antenna, and will be described hereinafter with reference to that application. This invention has particular merit when applied to passive transponders where high speed data transmission is desirable.

Background of the Invention

Hitherto, high speed data has been transmitted to RFID transponders by modulation of the excitation field. Generally pulse position modulation with 100% depth amplitude modulation of the excitation field is used. The excitation field is turned off for short intervals which are detected by the transponder's processing circuitry. To achieve high data rates while maintaining the transmission of power the intervals must be short and the duty cycle low. Typically a duty cycle of 10% is used and the intervals are 1μs long and the average time between intervals is 10μs. Short intervals such as these have a wide bandwidth. Accordingly, both the interrogator and the transponder require low Q factor, wide bandwidth antennae to transmit and receive the data. Low Q factor antennae are not energy efficient and, as such, the interrogator antenna will consume more power than a high Q factor antenna. Moreover, for passive transponders a stronger excitation field is required to compensate for the less efficient antenna.

Additionally, regulations governing the magnitude of electromagnetic emissions place upper limits on the strength of excitation fields that can be used and the allowable

bandwidth of an excitation field. The wide bandwidth of the prior art pulse, modulation data results in limitations being placed on the maximum excitation field strength.

Object of the Invention

It is an object of the invention, at least in the preferred embodiment, to overcome or substantially ameliorate at least one of the disadvantages of the prior art.

Summary of the Invention

According to one aspect of the invention there is provided a method for transmitting data from a first antenna, said method including the steps of:

providing a carrier signal;

imposing a low level quadrature phase modulation on the carrier signal in accordance with a data signal to create a modulated signal;

providing the modulated signal to said first antenna for transmission.

According to another aspect of the invention there is provided a transmitter including:

a first antenna;

oscillator means for providing a carrier signal; and

mixing means for imposing a low level quadrature phase modulation on the carrier signal in accordance with a data signal to create a modulated signal, the mixing means also providing the modulated signal to the first antenna for transmission.

Preferably, the modulated signal is received by a second antenna which in response thereto, produces a first signal which is provided to receiver means, the receiver means deriving a second signal indicative of the data signal. Even more preferably, the first signal is used to power the receiver means.

Preferably also, both the first and second antennas have a high Q factor.

In a preferred form, the modulated signal includes the sum of the carrier signal and an attenuated carrier signal which is quadrature phase modulated with the data signal.

In a preferred form the antenna is a coil that may be tuned.

Drawings

The prior art and preferred embodiment of the invention will now be described, by way of example only, with reference to the accompanying drawings in which:

Figure 1 is a schematic illustration of a prior art transponder circuit;

Figure 2 illustrates representative waveforms associated with the prior art circuit of Figure 1;

Figures 3(a) to 3(c) are frequency spectra associated with the waveforms of the prior art circuit of Figure 1;

Figures 4(a) and 4(b) are phasor diagrams for waveforms produced in accordance with the invention;

Figures 5(a) to 5(c) are frequency spectra associated with the invention;

Figures 6(a) and 6(b) respectively illustrate methods of encoding and decoding data in accordance with the invention;

Figure 7 is a schematic illustration of a preferred circuit for encoding the data signal for transmission; and

Figure 8 is a schematic illustration of a preferred circuit for decoding the data signal in the transponder.

Discussion of Prior Art

Passive RFID transponders that incorporate a single antenna are interrogated by an interrogator using an excitation field. This field is received by the transponder's antenna and the voltage induced on the antenna is rectified and used to power the transponder. Often it is necessary that the transponder to receive data transmitted from its interrogator. For single antenna transponders the received messages must be received by the same antenna that is used to receive the excitation signal used to power the transponder. In prior art systems the excitation signal is amplitude modulated to convey messages from the interrogator to the transponder.

Figure 1 shows a prior art transponder where the antenna L is tuned by a capacitor C and data is transmitted to the transponder by amplitude modulation. The voltage V1 induced in the transponder's antenna coil is magnified by the antenna's tuning, rectified by the rectifiers and stored on the DC storage capacitor Cdc for use by the transponder's electronic circuits. The antenna voltage is peak level detected by the diode envelope detector D1,C1 and R1 to give the envelope voltage V2.

Figures 2(a) and 2(b) illustrate waveforms associated with the prior art circuit of Figure 1. More particularly, Figure 2(a) shows the excitation voltage V1 with amplitude intervals to giving pulse position modulation. A low duty cycle is used, typically 10:1. Figure 2(b) shows the envelope of the voltage V2 induced in the antenna. The antenna's transient response results in a finite rise and fall time for V2. The transient time of the antenna must be sufficiently short to allow narrow pulses to pass without significant distortion. The antenna's transient response time constant Ts and bandwidth BW are related by $Ts=1/(BW.\pi)$. Accordingly, to pass short pulses the bandwidth of the antenna

must be broad. For example, to pass 1μs pulses a bandwidth of at least 1 MHz is required.

Figures 3(a) to 3(c) are frequency spectra associated with the prior art circuit of Figure 1. Figure 3(a) shows a typical data spectrum. For data at 100kbps the first zero of the frequency spectrum occurs at 100kHz. Figure 3(b) shows the data spectrum when encoded as pulse position modulation PPM where narrow low duty cycle pulses are used. The spectrum for this type of encoding is much broader than the original data spectrum. For 1μs pulses with a 10:1 duty cycle the first amplitude zero of the frequency spectrum occurs at 1 MHz. Figure 3(c) shows the spectrum of the excitation signal when modulated with the PPM signal whose spectrum is shown at Figure 3(b). The modulated spectrum is double sided and accordingly, for 1μs pulses with a 10:1 duty cycle the width of the main spectral lobe is 2 MHz. Clearly the bandwidth of the PPM modulated excitation signal is much broader than the original data spectrum.

To pass the inherently broad band PPM excitation signal both the interrogator and transponder antenna must have a wide bandwidth. Consequently the interrogator and transponder antennae must have a low Q and will operate with a low efficiency. In the interrogator the generation of 100% amplitude modulated PPM requires that excitation signal be completely quenched for each pulse. This requires a wide band antenna low efficiency antenna. Narrow band antennae would operate with high efficiency but are unable to respond to the narrow amplitude pulses of PPM. Similarly the transponder antenna bandwidth must be broad band enough to pass the modulated excitation signal. Broad band antennae are inherently low Q and are poor collectors of energy from an excitation field.

Preferred Embodiment of the Invention

In this preferred embodiment of the invention data is imposed as a low level quadrature phase modulation on the excitation field. This low level quadrature modulation appears as a tiny phase jitter in the excitation field. There is no change in the amplitude of the excitation field and hence the transmission of power to the transponder is unaffected. This form of modulation will be termed phase jitter modulation PJM.

To produce the signal at the interrogator, a small portion of the excitation signal is phase shifted 90 degrees, phase modulated with the data signal and added back onto the original excitation signal before being transmitted to the transponder. At the transponder these tiny phase shifts in the excitation induce corresponding antenna voltage phase shifts that are unaltered by any circuit impedances or power regulation circuitry connected to the transponder's antenna.

Figure 4(a) is a phasor diagram of the excitation signal Fc and the modulated quadrature signal PRK. The amplitude of the respective signals are given by their phasor lengths. The phase deviation THETA caused by the modulated quadrature signal is, for low level signals, extremely small and is given by:

$$\text{THETA} = \arctan(2\text{xMag(PRK)}/\text{Mag(Fc)})$$

For a 40dB attenuated PRK signal THETA=1.2 degrees and for a 60dB attenuated PRK signal THETA=0.12 degrees. Both of these are extremely small phase deviations of the excitation signal.

Phase quadrature modulation is recovered using a local oscillator (LO) signal, with a fixed phase with respect to the excitation signal, to down convert the modulated data to baseband in a mixer or multiplier. In the transponder the LO signal must be

derived from the modulated excitation signal. The preferred method of extracting a LO signal from the modulated excitation signal uses a Phase Locked Loop PLL in the transponder to generate the LO signal. The LO signal is generated by a low loop bandwidth PLL which locks to the original excitation signal's phase but is unable to track the high speed modulated phase shifts. The quadrature data signal is down converted and detected in a mixer or multiplier driven with the LO signal. Depending upon the type of phase detector used in the PLL, and the propogation delays through the circuit, the phase of the LO with respect to the excitation signal can be anywhere between 0° and 360°. If a conventional XOR phase detector is used in the PLL then the output of the PLL oscillator will be at nominally 90 degrees to the excitation signal and will be in phase with the data modulated phase quadrature signal. A 90° phase between the LO and the excitation signal is not necessary for the effective detection of quadative phase modulation. An XOR mixer has a linear phase to voltage conversion characteristic from 0° to 180° and 180° to 360°. Hence it gives the same output irrespective of the phase angle except around 0° and 180° where there is a gain sign change.

The average output voltage from mixers is a function of the phase difference. It is more convenient for circuit operation for the average output to be around midspan and hence an LO with a phase angle of around 90° is more convenient. The phase of the LO signal can be simply adjusted using fixed phase delay elements. Hence a 0° or 180° phase detector can be used and a further 90° (roughly) of phase shift can be achieved with a fixed delay element.

Figure 4(b) is a phasor diagram of the modulated excitation signal and the quadrature local oscillator signal in the transponder used to demodulate the data signal.

The local oscillator signals phase is at 90 degrees with respect to the excitation signal's phase.

For phase modulation the data bandwidth is no broader than the original double sided data bandwidth. When attenuated the level of the modulated data spectrum is extremely low and virtually undetectable with respect to the excitation signal amplitude making conformance to regulatory emission limits significantly easier than with the prior art.

Figures 5(a) to 5(c) are representative frequency spectra that explain the operation of the invention. More particularly, Figure 5(a) is a typical data spectrum. For data at 100kbps the first zero of the frequency spectrum occurs at 100kHz. Figure 5(b) is a representative frequency spectrum of the data when modulated onto a quadrature version of the excitation signal. The spectrum for this type of modulation is the same as the double sided spectrum of the original data spectrum. In the invention the modulated quadrature signal is attenuated and added to the original excitation signal. Figure 5(c) shows the spectrum of the excitation signal Fc plus the attenuated modulated quadrature signal whose spectrum is shown in Figure 5(b). The attenuation level is given by the difference between the amplitude of the excitation signal and the amplitude of the data sidebands. Attenuation levels of 60dB are achievable with this system and consequently sideband interference levels are so low that they should not be significant for regulatory emission purposes.

Since the spectrum of the transmitted excitation signal is equal to the original double sided data spectrum, narrow band high Q interrogator and transponder antennae are used to respectively transmit and receive the modulated excitation signal.

Consequently, the interrogator's excitation antenna operates with high efficiency and the transponder's antenna likewise receives energy with high efficiency.

Figures 6(a) and 6(b) show methods of modulating and demodulating according to this invention. Turning first to Figure 6(a), the portion of the main excitation signal is phase shifted 90 degrees to produce a quadrature signal. The quadrature signal is then modulated with data . The preferred form of modulation is phase reverse keying PRK. The PRK modulated quadrature signal is attenuated and then added back to the main excitation signal. Although shown in a particular order the sequence phase shift, modulation and attenuation are done in other orders in alternative embodiments. This method of modulation produces low level data side bands on the excitation signal where the sidebands are in phase quadrature to the excitation signal. The data signal appears as a low amplitude phase jitter on the excitation signal.

Figure 6(b) illustrates a method for demodulating the data modulated on to the excitation signal. A LO signal is generated by a low loop bandwidth phase lock loop PLL. The PLL locks on to the excitation signals phase and is unable to follow the high speed phase jitter caused by the data modulation. For the standard PLL phase detector the PLL oscillator will lock at a fixed phase with respect to the excitation signal's phase. This oscillator signal is then used as a LO to demodulate the quadrature sideband data signal in the multiplier. A low pass filter LPF filters out high frequency mixer products and passes the demodulated data signal.

Figure 7 shows an example circuit for encoding the data signal for transmission. An excitation reference source Fc is split through a 90 degree splitter. One output from the splitter is fed to the LO port of a mixer. Data is fed to the mixer's IF port and causes

PRK modulation of the LO port's signal. The output of the mixer at the RF port is a PRK modulated quadrature signal. This is attenuated and added back onto the reference by a zero degree combiner ready for transmission to the transponder.

Figure 8 shows an example circuit for decoding the data signal in the transponder. The transponder antenna voltage is squared up by a schmitt trigger, the output of which feeds a type 3 PLL. A type 3 phase detector is a positive edge triggered sequence phase detector which will drive the PLL oscillator to lock at 180° with respect to the input phase with a low loop bandwidth the PLL is able to easily filter off the sidebands on the input signal The output of the schmitt is passed through a chain of invertors desinged to add a fixed delay to the input signal. The delay is approximately chosen and so that the phase of the output from the delay chain is not 0° or 180° with respect to the LO. A preferred phase value is 90° for circuit convenience. The output of the VCO acts as the LO to demodulate the Phase Jitter Modulated data. The data is demodulated in an exclusive OR gate, the output of which is low pass filtered and detected with a floating comparator.

Although the invention has been described with reference to a specific example it will be appreciated by those skilled in the art that it may be embodied in many other forms.

AUSTRALIAN SEC 113 PATENT OFFICE

DATED THIS 24th Day of December, 1997
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~~ILAMON PTY LTD~~

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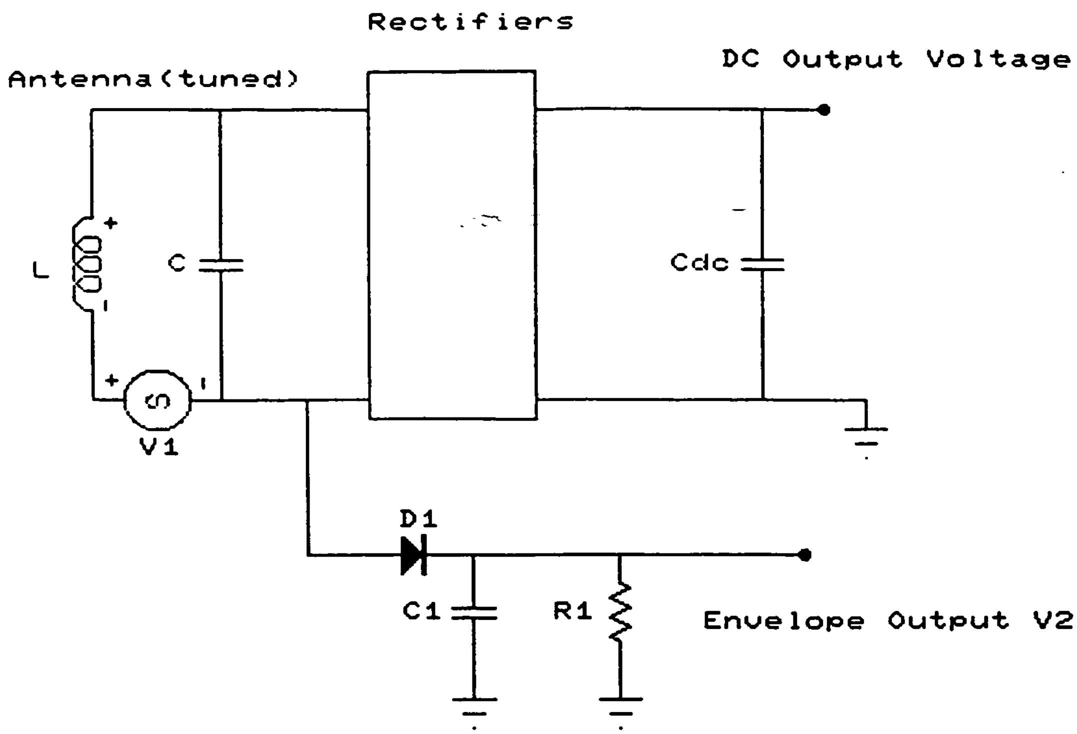

Figure 1 : Prior Art Transponder

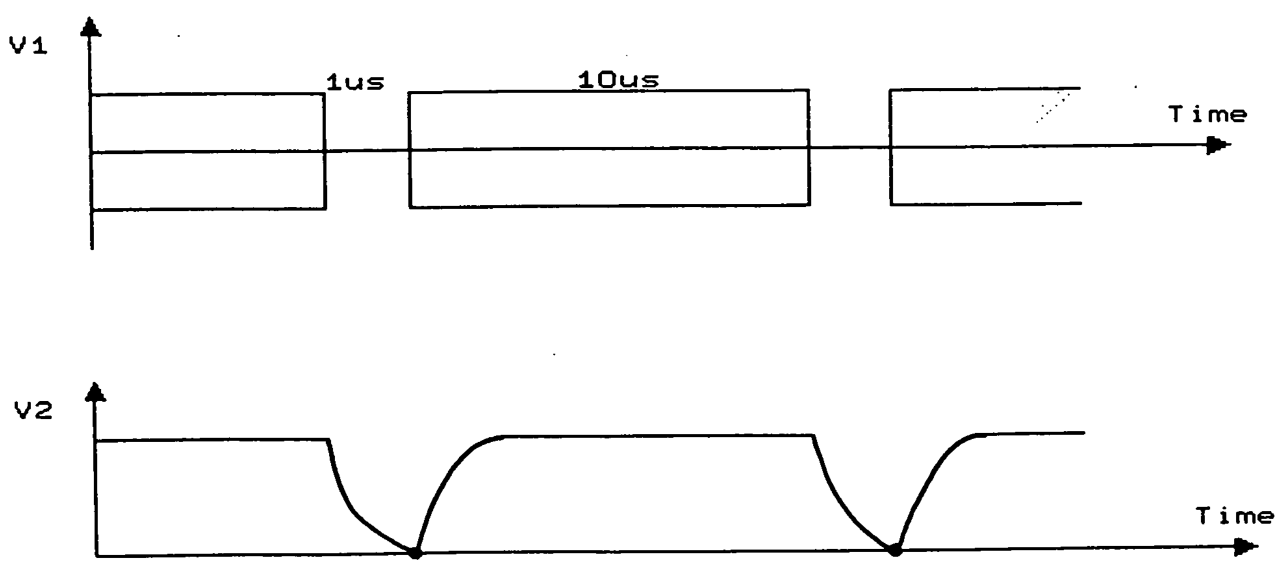

Figure 2 : Excitation V1 and Detected Envelope V2

Figure 3(a) : Data Spectrum

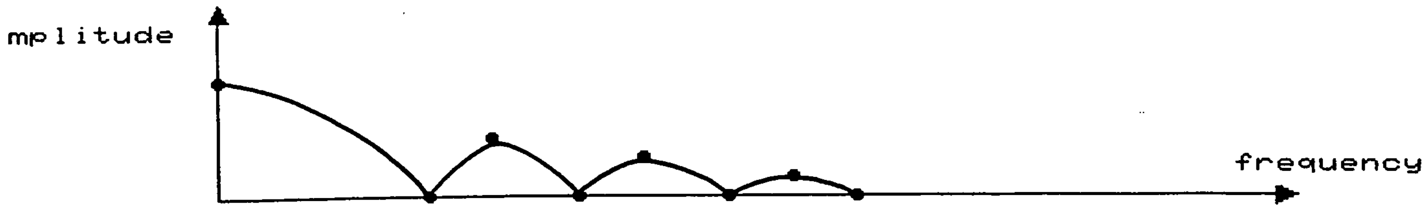

Figure 3(b) : Pulse Position Spectrum

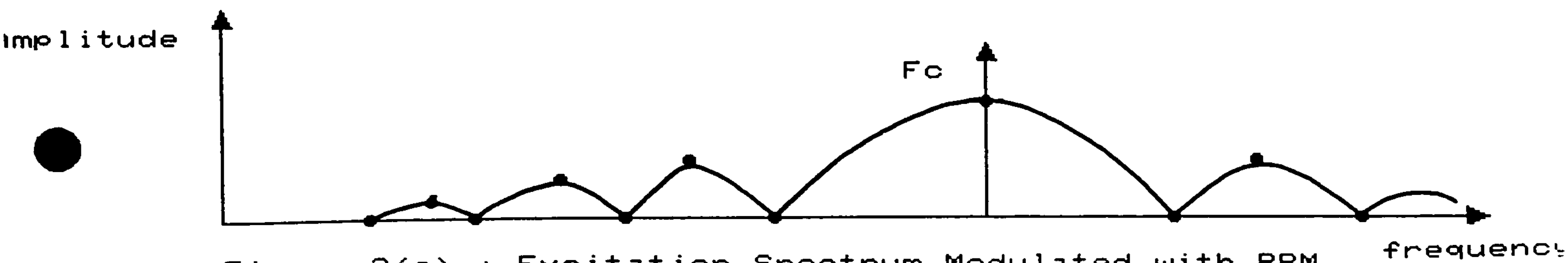

Figure 3(c) : Excitation Spectrum Modulated with PPM

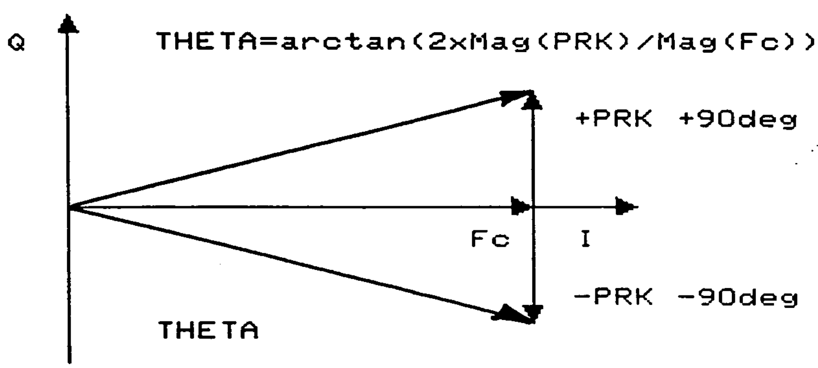

Figure 4(a) : Phasor diagram showing Excitation and Modulation

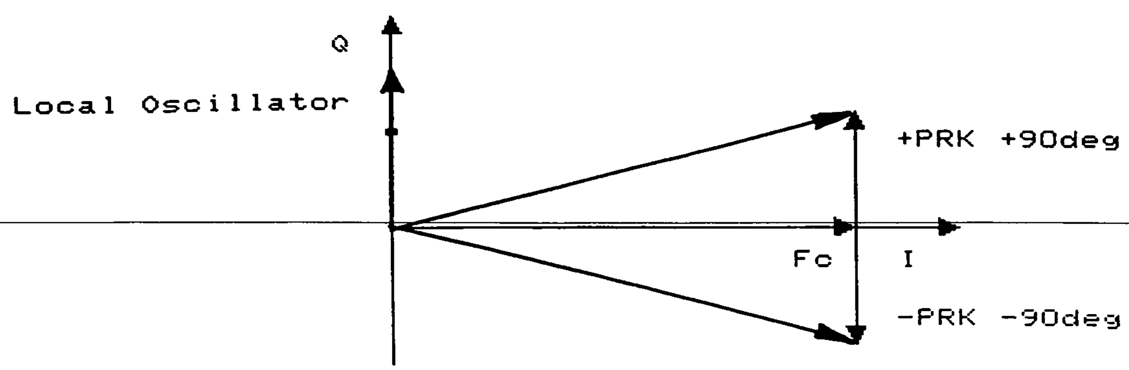

Figure 4(b) : Phasor diagram Showing Local Oscillator at 90deg to Fc

Figure 5(a) : Data Spectrum

Figure 5(b) : Data Modulated Quadrature Excitation

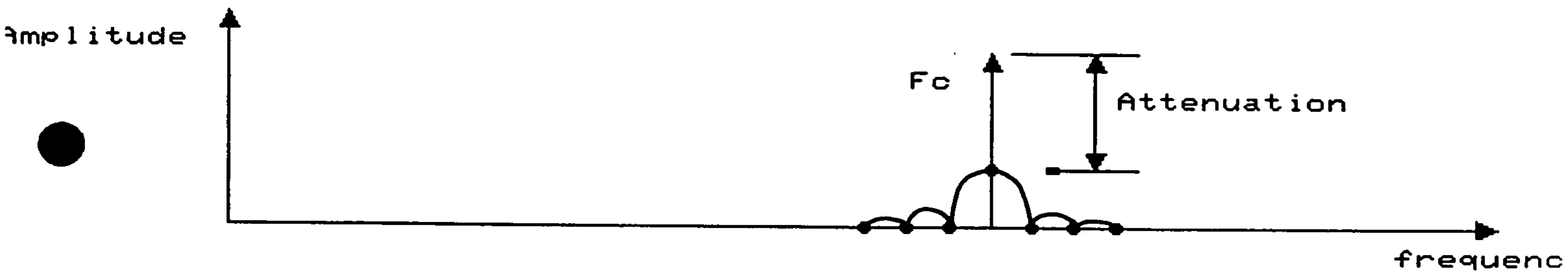

Figure 5(c) : Excitation Spectrum plus Attenuated Quadrature Modulation

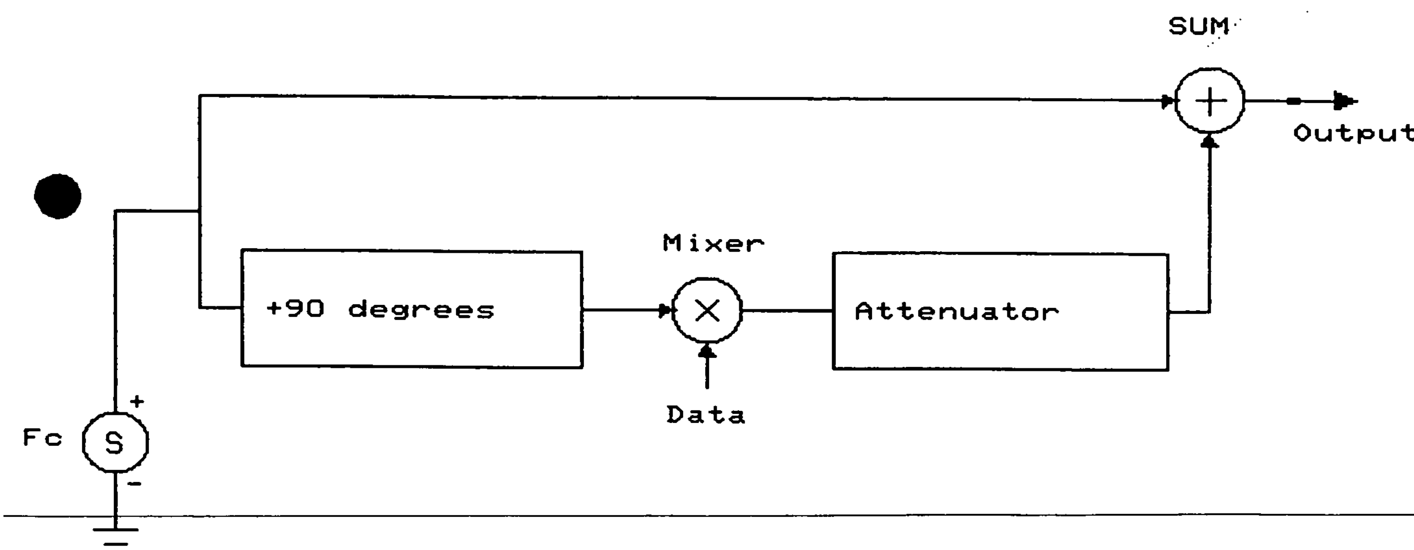

Figure 6(a) : Method of Modulating Excitation Signal

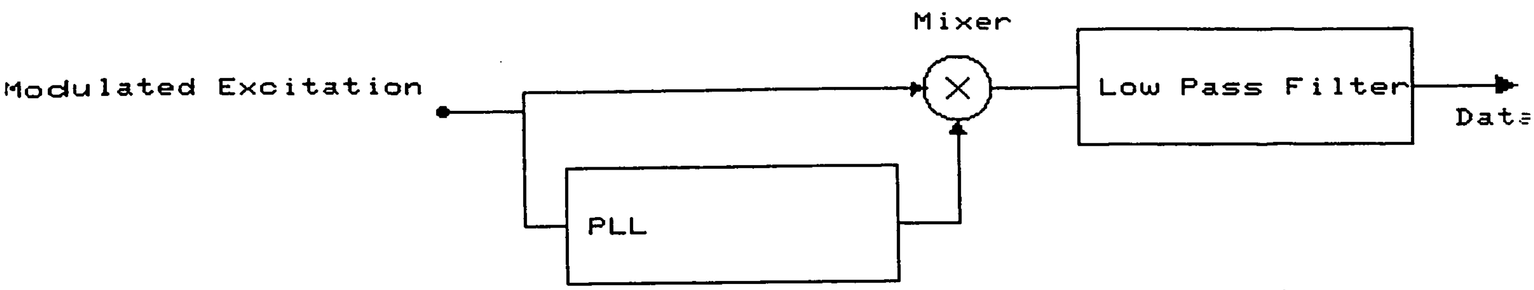

Figure 6(b) : Method of Demodulation

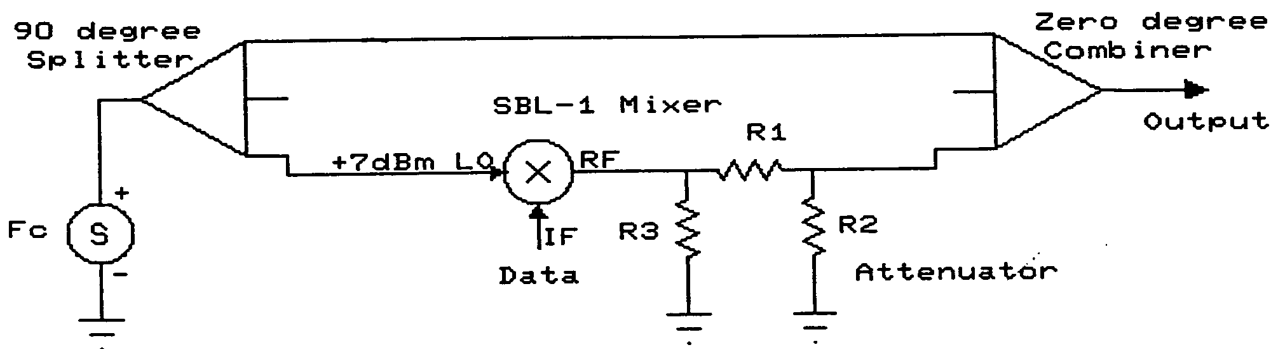

Figure 7 : Example Circuit for Modulating

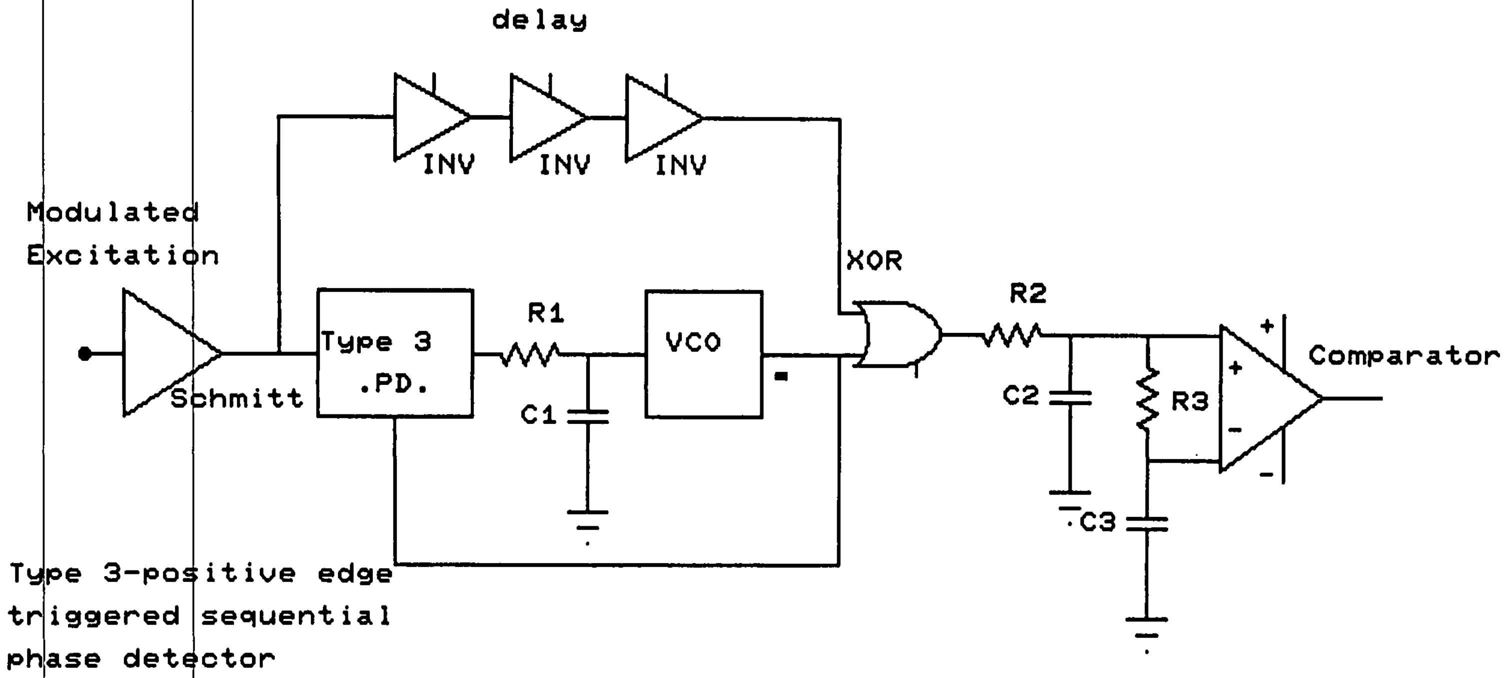

Figure 8 : Example Circuit for Demodulating

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